General Index to the Memoirs.

The Index to the *Monthly Notices* has been found so useful and acceptable to the Fellows, that the Council gave instructions to the Assistant-Secretary to prepare a General Index to the *Memoirs*, uniform with the Index to the *Monthly Notices*, including all the titles of Papers and the names of the authors contained in Volumes I.–XXXVIII. The work was completed by Mr. Williams during the recess, and placed in the hands of the Fellows in November last. The two Indexes thus form a complete catalogue of the numerous contributions towards the progress of our science which have been laid before the Society from its foundation to the present time.

Obituary.

The Council have to deplore the loss by death of a long list of Fellows, several of whom were distinguished astronomers and former officers of the Society. Sir John Herschel and Mr. Babbage were the last survivors of the small band of scientific men who met together at the Freemasons' Tavern on January 12th, 1820, "to take into consideration the propriety and expediency of establishing a Society for the encouragement and promotion of astronomy," a meeting which resulted in the foundation of the Royal Astronomical Society. The following list contains the names of the deceased Fellows:—

Fellows:—Charles Babbage, Esq., F.R.S.
Capt. J. Palladio Basevi, R.E.
Rev. A. W. Deey.
Augustus De Morgan, Esq.
Lt.-Gen. Sir W. T. Denison, K.C.B., F.R.S.
Earl of Dunraven, F.R.S.
Capt. R. W. H. Hardy, R.N.
Sir J. F. W. Herschel, Bart., F.R.S.
Sir A. Lang.
Sir Roderick I. Murchison, Bart, K.C.B., F.R.S.
Admiral Sir William Ramsay, K.C.B.
William Rutherford, Esq., LL.D.
Charles E. Smith, Esq.
Capt. David Smith.
Rev. William Taylor, F.R.S.
Rev. T. W. Weare.

Charles Babbage was born on St. Stephen's day, 26th December, 1792, and died on 18th October, 1871, aged nearly seventy-nine years. His parents were of good standing in the middle class. His early education, which commenced at five years, was conducted at various private schools, whence, after a

short sojourn with a private tutor, he was sent at the usual age to the University of Cambridge.

His love of investigation, which became the ruling passion of his life, was displayed when quite a child, and was first evinced by an experiment which he made in order to ascertain whether or not the Devil could really be raised in a personal form. The result, which was negative, removed a doubt which had obscured his religious belief, and his theological views seem from that time to have enjoyed undisturbed stability.

Babbage, like many men of great and original powers, made light of ancestry. Discussing the possibility that he might be descended from Tubal Cain, on the ground that he was, like himself, a great worker in iron, he pointed out that this hypothesis is shaken by the fact that to Tubal Cain is ascribed the invention of the *organ*, an instrument against which the subject of this notice, as is well known, carried on an incessant war.

It does not appear that Babbage owed either his tastes or his acquirements to external influences. Before going to Cambridge he had already, following his innate tendencies, plunged deeply into arithmetical and mathematical studies, reading such works as Humphrey Ditton's *Fluxions*, Agnesi's *Analytical Institutions*, Woodhouse's *Principles of Analytical Calculation*, Lagrange's *Théorie des Fonctions*, and the *Fluxions* of Maclaurin and of Simpson; and when he went to Cambridge the *dots* of Newton, the *d*'s of Leibnitz, and the *dashes* of Lagrange were equally familiar to him.

Discursive and unassisted studies led, as they usually do, to independent habits of thought. His acquirements lay rather outside the established system of the University, and the difficulties he necessarily encountered seem to have been difficulties to the tutors to whom he vainly resorted for their solution. His confidence in the routine of the place was shaken, and he presumed to think for himself. Turning to the works of foreign mathematicians, he was "penetrated with the superior power of the notation of Leibnitz."

But he was not alone. A society for the promotion of analysis was formed at his suggestion, amongst the first members of which stand the names of Herschel, Peacock, D'Arblay, Ryan, Robinson, and Frederick Maule. They held meetings at which papers were read and discussed. The first volume of *Transactions* published was exclusively the work of Herschel and Babbage,—the latter proposing as its title "The Principles of D-ism in opposition to the Dot-age of the University." Persisting in these revolutionary schemes, Babbage, assisted by Peacock, translated the smaller work of Lacroix. Peacock, Herschel, and Babbage, afterwards published a collection of examples with their solutions: Peacock of the applications of the differential and integral calculus, Herschel of those of the calculus of finite differences, and Babbage of the solutions of functional equations. This work, by lightening the labours of the tutors, obtained their support, and

contributed much to the introduction of the system. "In a few years," says Babbage, "the change was completely established; and thus at last the English cultivators of mathematical science, untrammelled by a limited and imperfect system of signs, entered on equal terms into competition with their Continental rivals." Babbage had previously published an essay on the Calculus of Functions, and memoirs on the same subject. The creation of this as yet insufficiently-cultivated branch of analysis may in fact be considered as due to him.

Babbage's time and thoughts at Cambridge were not wholly engrossed by mathematics,—he worked with Herschel, under Smithson Tennant, at chemistry,—nor did his various studies suffice to employ his exuberant energy,—he joined in the amusements of the place, devoting himself particularly to boating with the vigour that so conspicuously characterized him.

It was here, in 1812 or 1813, that the first idea of a calculating machine germinated in his mind,—an idea that shaped his whole life, and fixed his name for ever in the history of Science.

It is impossible in a brief notice like the present to give a detailed account of this wonderful mechanical substitution for intellectual operations. A few leading facts may however be mentioned. The first engine designed by Babbage was named by him the "Difference Engine," its object being to compute tables by the method of differences, an object attainable by means little beyond that required for performing the arithmetical operation of addition. But the performance of this apparently simple task involves the process of carrying over the tens,—and to do this by mechanical means constituted the main difficulty of the undertaking,—a difficulty the solution of which occupied even the mind of Babbage during a long series of years.

After considerable progress had been made by Babbage in the construction of the "Difference Engine," an idea of a still higher order occurred to him,—that of an "Analytical Engine,"—a machine not for mere tabulating like the Difference Engine, but for calculating out any formulæ presented to it. Its principle seems to have been based upon, if not suggested by, that of the Jacquard loom, which, as Mr. Babbage points out, "is capable of weaving any design which the imagination of man may conceive." These designs, as is well known, are reproduced in the fabric by means of perforated cards, a distinct set of cards being required for each different design. Applying this principle to the Analytical Engine, each operation required two distinct sets of perforated cards,—one appertaining to the formula to be developed, the other containing the constants belonging to the particular case of which a solution was desired. The first set of cards prepared for a given formula would at any time recalculate that formula with whatever constants were furnished to it by the other set. The engine, therefore, was quite general in its application.

Besides performing these main operations, the machine was designed to execute the following subsidiary work:—To print on

paper one or two copies of its results; to produce a stereotype mould of the tables or results computed by it; and to punch on blank pasteboard cards or metal plates the numerical results of any of its computations. The speed with which its work should be executed was almost as astonishing as the work itself. It would multiply fifty figures by the same number in one minute.

Such was the complexity of these marvellous engines that even their gifted inventor found it difficult to interpret to himself his own drawings. He was also embarrassed by the number of modes of producing the same action suggested by his prolific inventiveness. Nor could he rest satisfied with less than a *demonstration* that the mode selected was the best. To meet these fundamental difficulties he found it absolutely necessary first to invent a system of Mechanical Notation, such that when applied to his drawings it should give at once, by simple inspection, without any verbal description whatever, all the elements required for explaining the nature, position, object, and effect of every part of the machine depicted.

His paper, descriptive of this system, which is of universal application, "On a method of expressing by Signs the Action of Machinery," was read before the Royal Society, on the 16th of March, 1826. This memoir alone would confer celebrity on its author.

Mr. Babbage was justly proud of his system of Mechanical Notation, and was fond of performing the following feat to exhibit its powers. He would request his visitor to select one from the hundreds of drawings before him, executed perhaps ten years previously. Turning his back on the drawings, he desired his visitor to place his finger on any part of it. He then asked him a few questions as to the letters and symbols on or near that part,—whether they were upright or sloping, large or small, Arabic or Roman, and so on,—and he then, without any apparent exercise of thought and without any hesitation, described the part, its function, position, and relation to the whole. It was his opinion that this system of Notation was as indispensable to the designing of the engine as tools were to its construction.

The history of these marvels of intellect has often been told, and is sad indeed. For a full and trustworthy account of it, the reader is referred to Weld's *History of the Royal Society*. A mere outline only can be here given.

It was proposed that the Government should contribute to the construction of the "Difference Engine." The question was referred to a committee of the Royal Society, consisting of Sir H. Davy, Mr. Brande, Mr. Combe, Mr. Francis Baily, Mr. Brunel, Major Colby, Mr. Davies Gilbert, Sir John Herschel, Captain Kater, Mr. Pond (Astronomer Royal), Dr. Wollaston, and Dr. Young. This most competent tribunal reported favourably on the project, stating that "they considered Mr. Babbage as highly deserving of public encouragement in the prosecution of his arduous undertaking." Funds were accordingly provided by Govern-

ment from time to time, but being never adequate in amount, Mr. Babbage himself contributed largely to the expenses from his own resources. Time went on, the works proceeded, and the design not only grew, but became productive of new ideas. The conception of the Analytical Engine resulted. No sooner did this advance in the subject appear to its author capable of practical execution than, with characteristic candour, he felt bound to communicate it to the Government, as affecting the question whether, with such a prospect of almost boundless powers of mechanical calculation before them, they would persevere in the construction of the more limited Difference Engine. For seven years Mr. Babbage's applications to various ministers and administrations failed to elicit an answer to this simple question. At length, on 4th Nov. 1842, the answer came from Mr. Goulburn (Chancellor of the Exchequer in Sir Robert Peel's Cabinet), regretting that, on the grounds of expense, the completion of the machine must be abandoned, and offering to place at Mr. Babbage's disposal all that existed of it. This latter offer Mr. Babbage declined, feeling that he had no right to accept public property which he perhaps considered the Government had no right to bestow upon him.

It is no part of our intention here to revive the personal animosity which the whole management of these transactions naturally excited. But we may extract a lesson from them. It must be evident to any one who studies the documents connected with the case that the inconsistencies and narrowness of view apparent in them arose mainly from the fact that there was no provision in the Government for the proper consideration of such a question—no minister, no department, no official advisers, who could properly be made responsible for thoroughly investigating the matter, and for pronouncing a well-weighed decision upon it. The consequence was, that in the press of party politics, no one minister would give the requisite attention to such a matter. The advice of the Royal Society, twice given in most decided terms in favour of Mr. Babbage's proposal, not being official, was ultimately disregarded; and the pretext of expense, always ready when the object of the expenditure is not understood, was, as has often happened in similar cases before and since, turned to account.

The deficiency in our administration, which operated unfavourably in this famous case, still exists. In a country which produces, it is true, but one Babbage in an age, yet teems beyond all other countries with inventors ready to devote their genius to the public good, there exists, as yet, no public functionary charged with the examination of the thousands of inventions, and discoveries, and projects of which, with enormous advantage to the country at large, the Government might readily avail themselves. The archives of this Society are not without records of difficulties in connexion with its own branch of science, in which the want of

a minister competent to deal with astronomical undertakings requiring State aid, has been felt.

To return to the subject of this notice. Mr. Babbage states that the following sums were spent upon the Difference Engine:—by the Government, about 17,000*l.*; by himself, upwards of 20,000*l.* The part completed was deposited in the Museum of King's College. Thence it was removed, through the great personal exertions of the late Mr. Gravatt, C.E., to the International Exhibition of 1862; after the closing of which it was transferred to the South Kensington Museum, where it now remains.

Babbage now turned his mind to the Analytical Engine; but experience told him how great must be the cost of such a work, the difficulties of which were moreover increased by the dearth of skilful draftsmen drawn away by the railroad mania, then at its height. In this doubt he had recourse to the advice of his mother. It was given in words worthy the mother of such a man: "My dear son," she said, "you have advanced far in the accomplishment of a great object, which is worthy of your ambition. You are capable of completing it. My advice is, Pursue it, even if it should oblige you to live on bread and cheese." He nobly pursued it accordingly, with unremitting toil of mind and body, as long as mental and bodily powers remained to him.*

Labours such as these would have sufficed to occupy the energy of most men. Not so Babbage. His other contributions to science and to human knowledge generally were so extensive that only some of the principal results can here be mentioned.

His memory will always be revered in this Society, in consequence of his being one of its founders, and one of its most steady supporters, until the latest period of his active life. He was very proud of being the recipient of the first medal ever awarded by the Society.

In 1828 Mr. Babbage was appointed to the Lucasian Professorship of Mathematics in the University of Cambridge, a chair which had been previously filled by some of the most distinguished mathematicians of this country, including Dr. Barrow, Sir Isaac Newton, Prof. Woodhouse, and the present Astronomer Royal. This chair he held till 1839.

He took a prominent part in the founding of the British Association for the Advancement of Science, the Statistical Section of which he established. He was also the original proposer and founder of the present Statistical Society of London.

He found time to write much. His *Economy of Manufactures* is a standard work of the highest authority on the subject. His *Passages from the Life of a Philosopher*, written more

* The best account of the principles on which this engine is based is that by Menabrea, of which a translation into English, and at Babbage's suggestion extensively annotated, was made by Lady Lovelace, the daughter of the poet Byron.

recently, though containing some personal allusions which are to be regretted, but hardly to be wondered at, is one of the most interesting and amusing autobiographies ever written. His contributions to scientific and learned societies were very numerous, exceeding perhaps one hundred. They relate to almost every branch of science, physical and social; and their author being one who disdained smatterings of knowledge, and searched always for the elementary basis of every subject he undertook to examine, there is not one of these papers that does not exhibit the mastery of an exact and comprehensive mind.

The indirect effects of Babbage's principal labours cannot be estimated, and will probably never be duly appreciated but by a few. The discoveries and improvements introduced by him in the art of metallic construction are innumerable. The shaping of metals by automatic machinery, now so well understood, was an art in its infancy when Babbage was first compelled, by the necessities of his designs, to turn his attention to it. Others laboured contemporaneously at the same problems, and the names of Clement, Bryan Donkin, Maudsley and Whitworth, cannot suffer by being coupled with that of Babbage.

It is impossible in a small compass to give an adequate estimate of such an intellect. Its salient features were universality, grasp, method, patience. What do not these four qualities, inspired by intense love of truth and never-flagging enthusiasm, and sustained by enormous power of work, imply? A man to whom no branch of knowledge was distasteful or difficult,—none too large or too minute,—who by the searching faculty of analysis could, sweeping aside superficial subsidiary complexities, dive straight to the fundamental principle,—and to whom weariness and wavering were unknown weaknesses,—possessed endowments before which most obstacles must have yielded. All careers were open to such a man. In any he must have succeeded. Unhappily for himself, he chose a path which, though no other man that ever lived could perhaps have trodden it as he did, led only to loss of fortune and embitterment of mind; and though to fame, to the fame which to many will be for ever a mystery, and to the few who can prize it perhaps a regret. It is as a scientific mechanician that Babbage will hereafter, no doubt, be regarded. In this field he had no equal. The combination of the highest mathematical genius with a lofty and vivid imagination, and the power of descending to the most minute details of technical construction, has never been observed in the same degree, and well-balanced harmony of proportion, as in Babbage.

Some idea of Babbage's versatility may be gathered from the mention of some of the subjects on which he wrote—Glaciers; Uniform Postage; Parcels Post; Submarine Navigation; Magnetic and Electric Rotations; Light-houses; Light-signals; Telegraphs; Geology; Miracles; Monopolies; Locks and Lock-picking; Division of Labour; Taxation; Commerce; Wood-engraving; the Diving Bell; Games of Skill; besides numerous

contributions to Astronomy, Mathematics, and Mechanics. He wrote also the ninth *Bridgewater Treatise*. It may safely be said that he never wrote without previous study, and that nothing he has written can be read without both stimulating thought and conveying instruction.

As a man he was equally admirable — generous, just, truth-loving, disinterested beyond most men — he had the faculty of endearing himself to those who knew him. Though immersed in the most abstruse pursuits, he was yet full of human sympathies, mixing habitually during his most busy years, in the society and even in the gaieties of the Metropolis. His conversation was so easy and his nature so genial, that, wherever he went, he was a centre of attraction, particularly with the fair sex, with whom he was always a favourite. In the various notices of him that have appeared, one of his most marked qualities is strangely overlooked — namely, his love of humour; this was so strong a characteristic that, to omit it, is to omit half the man. In his most serious, and even in his most indignant moods, he would always turn aside to exhibit the ludicrous side of the question; and, to a deep-seeing intellect like his, what question has not its laughable aspect? In conversation, as in his writings, he was very fastidious in the choice of his language, which possessed the charm of power united with simplicity in a high degree. Though he entertained a high estimate of his own powers and acquirements, he was always as ready to learn as to teach; and he would seek instruction from the humblest sources. An artisan skilful in some special matter had in him a patient and deeply interested listener.

This notice, brief as it is, would hardly be complete without some allusion to Mr. Babbage's constant endeavours to suppress street music and street nuisances — for, to a considerable mass of his countrymen, he is only known as the prosecutor, or, as they may have thought him, the persecutor, of organ-grinders. When it is stated that, according to the estimate of a man so remarkable for exactness and truth, one quarter of his time was wasted by the interruptions caused by such noises; and when it is considered what that implies in the case of one who never worked languidly, but whose every available moment was employed in deep and sustained thought, the extent of this grievance will be properly appreciated. The mental distraction which external noises caused him was part of a highly sensitive organisation, — an organisation frequently associated with yearning aspirations after unattainable refinement and perfection. His case is that of many students and workers. John Leech, the famous artist, suffered severely, if not fatally, from the very same cause. Mr. Babbage put the law in action, and it utterly failed to protect him. It is not surprising that he should complain bitterly — as less eminent men than he do daily when they find that in London, beyond any place in the civilised globe, the comfort of the many is deliberately sacrificed, in this, amongst many other ways, to the vested interests of a few.

Those who only know Babbage's name in connexion with this matter, and imagine him to have been a mere peevish visionary, require to be told that no man ever more truly loved his kind, and that few men have devoted transcendent powers like his with such disinterestedness, such tenacity, and such noble self-sacrifice, to what he believed to be the profit and the elevation of humanity.

A. S.

CAPTAIN JAMES PALLADIO BASEVI, R.E., was a son of the celebrated architect who designed the Fitz-William Museum at Cambridge, and other important buildings, and lost his life by falling from the tower of Ely Cathedral while superintending the restoration of that edifice.

James Basevi was distinguished as a lad for more than ordinary talent, and for his mathematical abilities. After passing with great credit through Rugby, the Cheltenham College, and the Honourable East India Company's Military Seminary at Addiscombe, he obtained a commission in the Corps of Engineers as first of his term, and went out to India in the year 1853. Three years afterwards he was appointed to the Great Trigonometrical Survey of India, upon which he continued to serve up to the time of his death. He was particularly qualified for this branch of the public service, and his excellent abilities being associated with remarkable powers of perseverance, and an entire devotion of self to duty, he was soon acknowledged to be one of the most valuable officers of the Department with which his interests were inseparably bound up. He took a prominent part in each of the various branches of the operations, the triangulations, linear measurements, topography, and mathematical reductions; he completed two chains of principal triangulation of an aggregate length of nearly 300 miles, mostly over very difficult ground; he supervised the measurement of a base-line at Cape Comorin, with Colby's apparatus of compensation-bars and microscopes, and wrote a valuable paper on the probable errors of the measurement, which is printed among the Appendices to *The Account of the Operations of the Great Trigonometrical Survey of India*, Vol. i. Dehra Doon, 1870.

In 1864 Captain Basevi was selected to undertake the Pendulum Operations which were commenced at the suggestion of the President and Council of the Royal Society, for the purpose of determining the variations of the force of gravity at certain stations of the great meridional arc in India, which was measured by Colonels Lambton and Everest, and at stations on the coasts and in the interior of the British territories in Asia. The object of these operations was two-fold; first, to obtain additional data to combine with the result of similar operations in other countries for determining the figure of the Earth; and, secondly, to ascertain the magnitude of the variations which are superposed, in certain localities, on the normal increase of gravity from the equator to the poles, in order that, by comparing the force of gravity on